Studying the Medium Response by Two Particle Correlations

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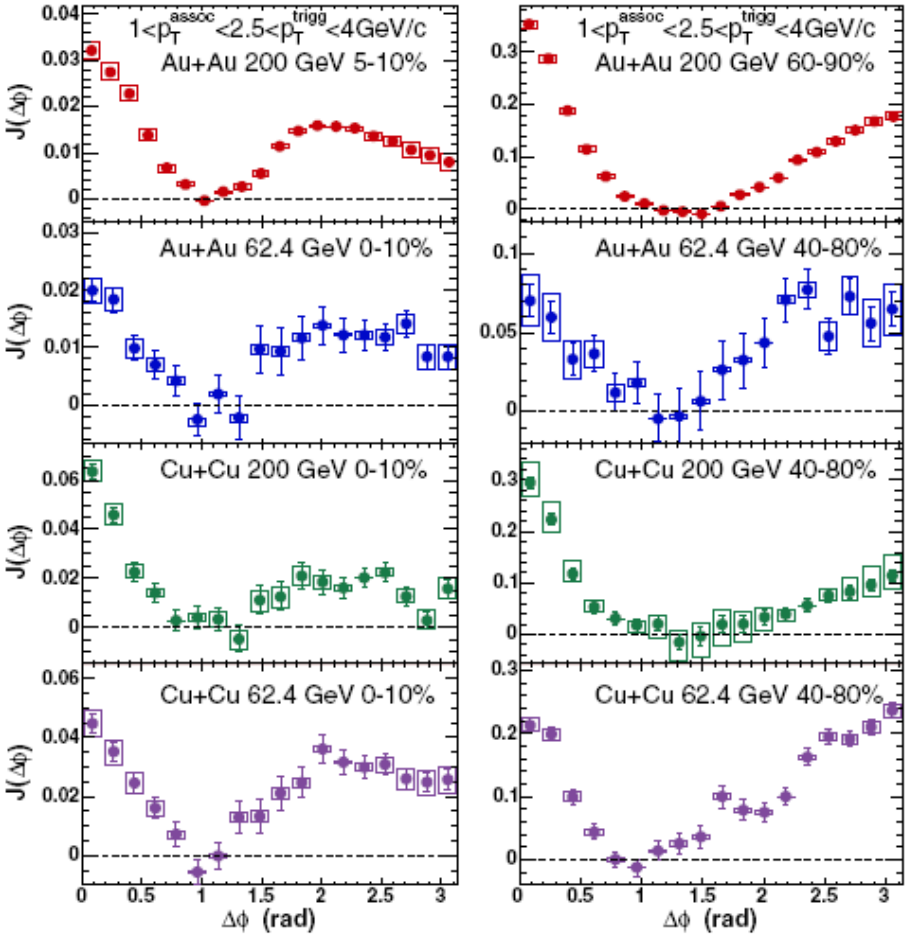
Workshop on "Saturation, the Color Glass Condensate and Glasma: What Have we Learned from RHIC?"

Outline

- Medium modification in near and away side
- Comparison between ridge and shoulder
- The momentum flow

The jet is modified!



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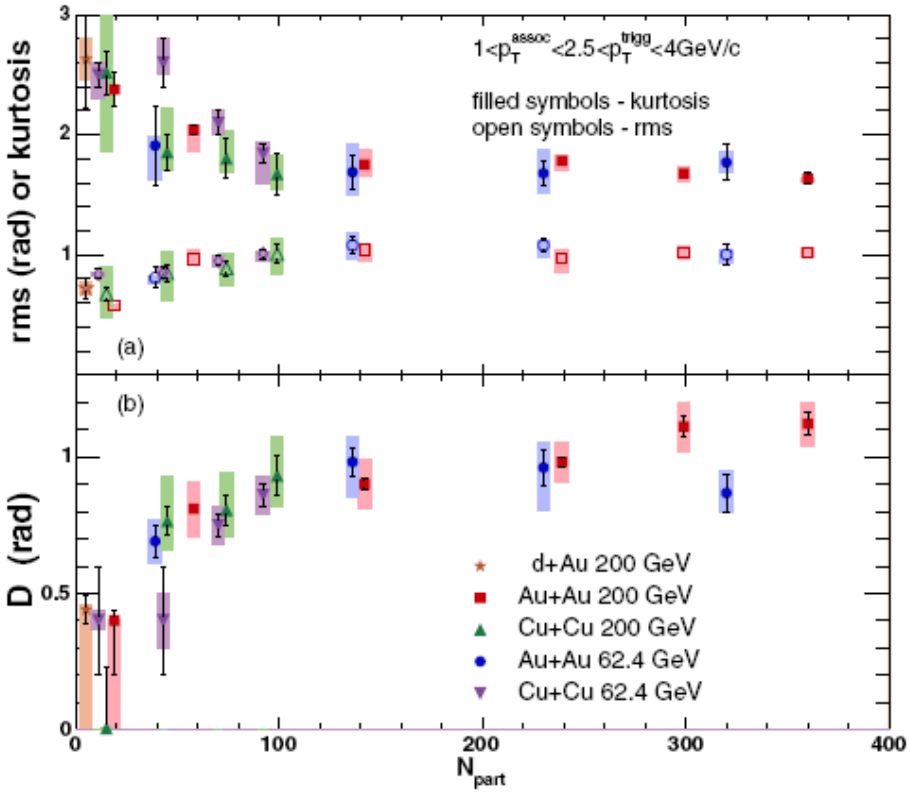
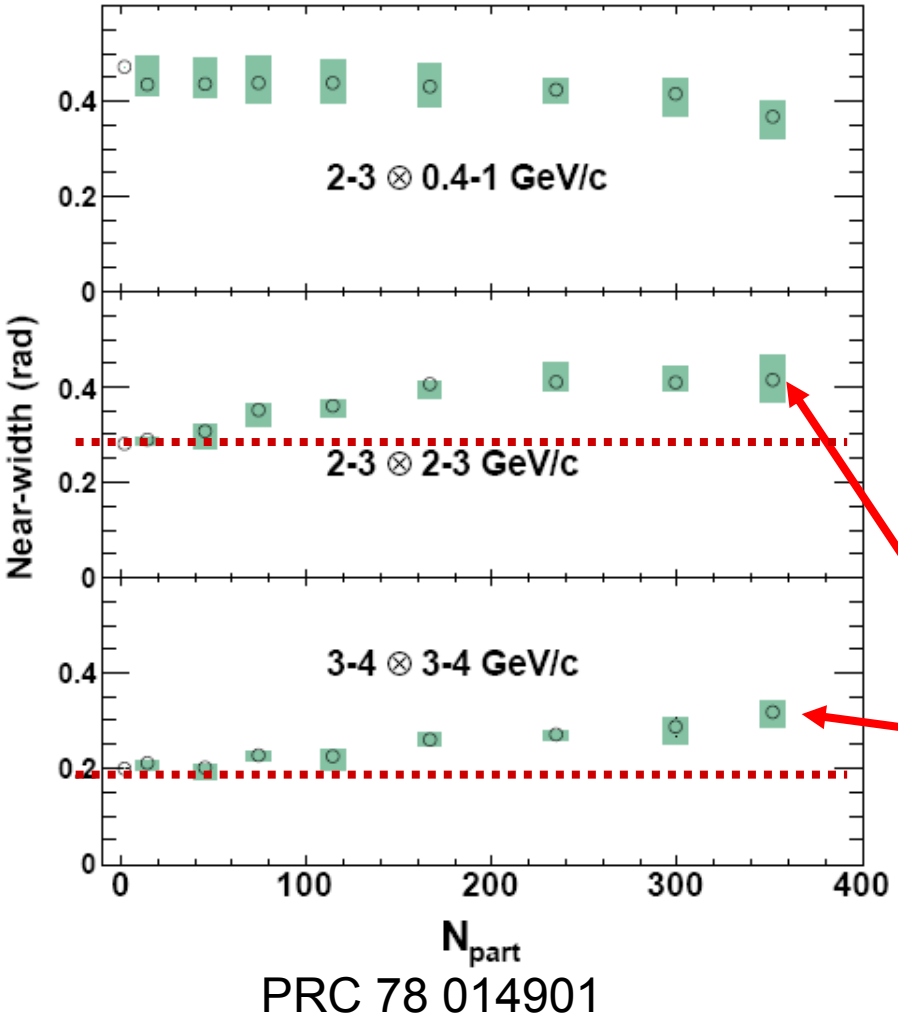


The awayside peak moved to ~ π +/- 1.1 in central collisions!

The nearside is also modified!



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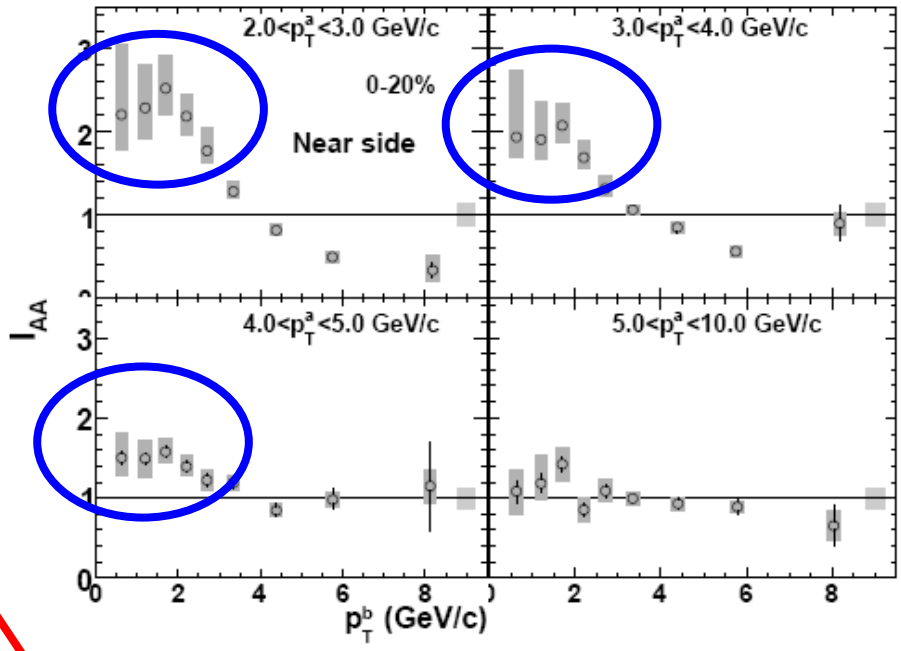
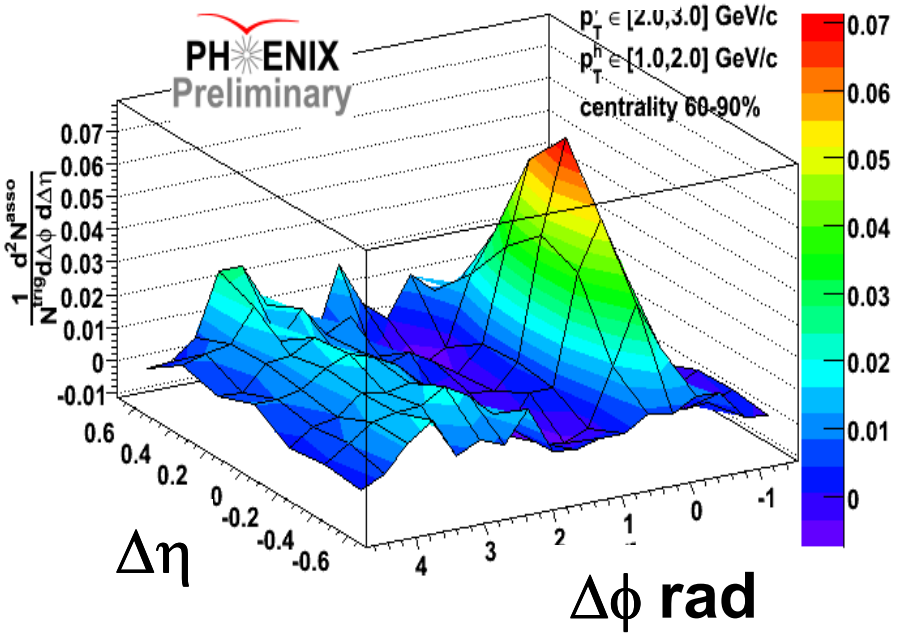


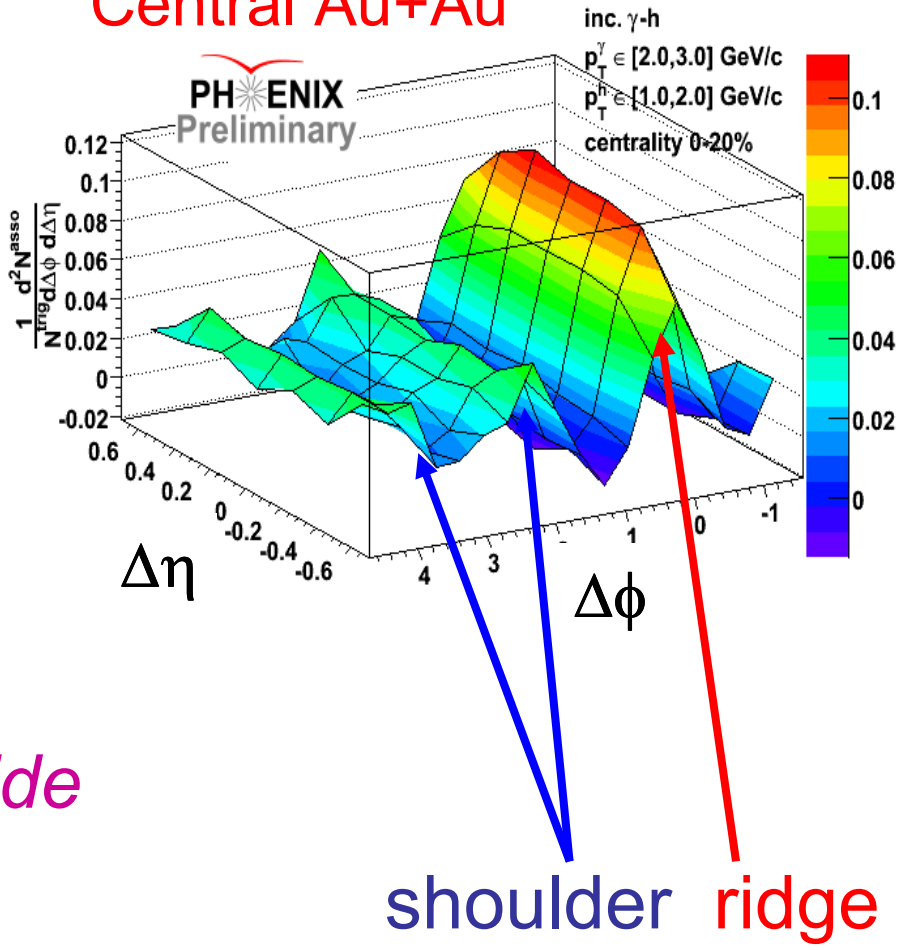
- The nearside width is wider than pp
- The yield at low partner p_T is also larger than pp

2-D $\Delta\eta-\Delta\phi$ correlations

Peripheral Au+Au

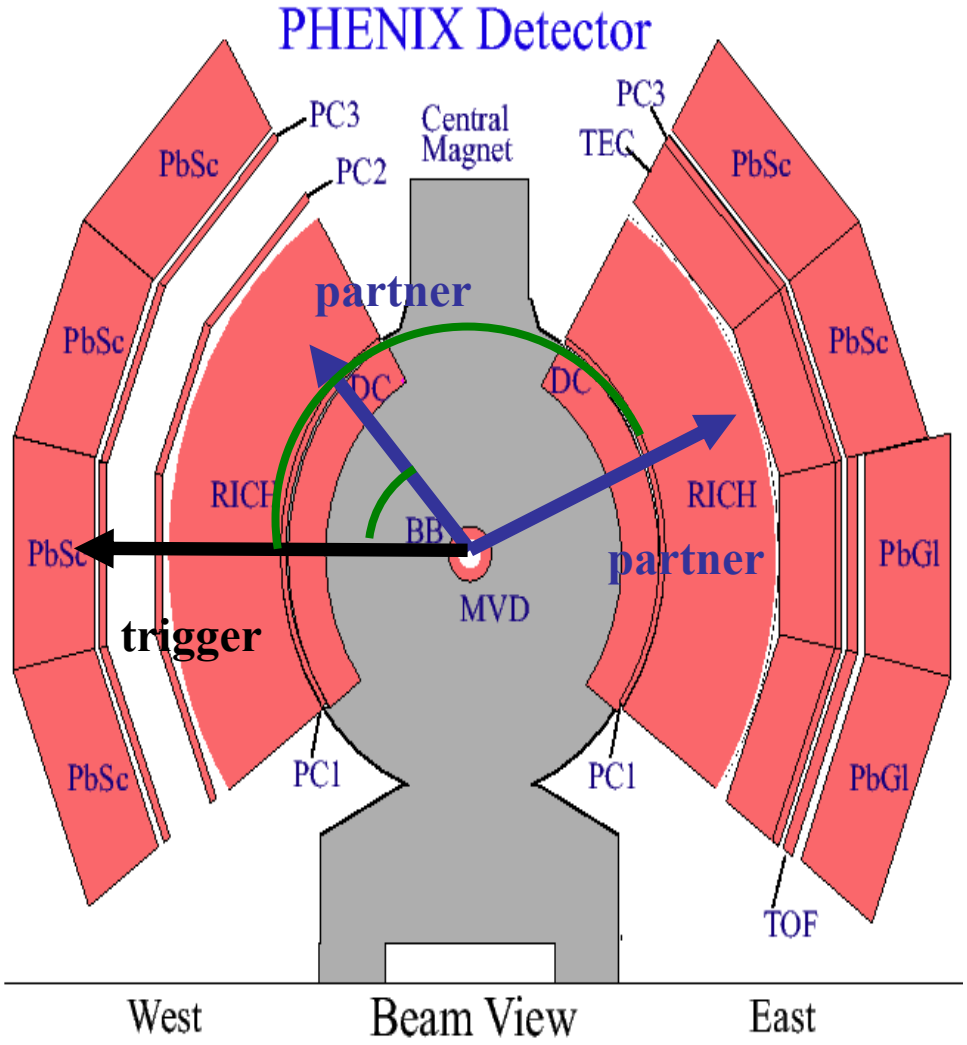


Central Au+Au



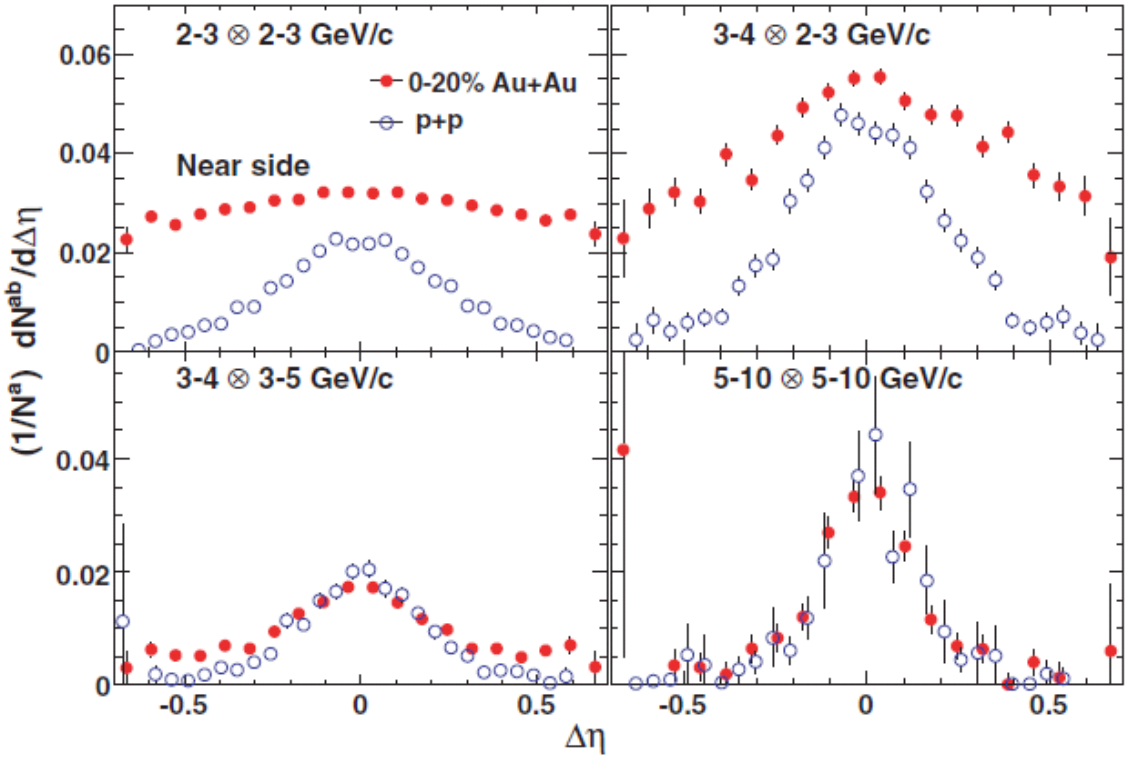
Both near and away side are modified!

Method



- Inclusive photon – hadron $\Delta\eta-\Delta\phi$ correlation
  - Trigger: inclusive photon
    - p_T: 2-3 GeV/c
    - Mostly π^0 decays
    - Not thermal photons!
  - Associated: inclusive charged hadron
    - p_T: 1-2, 2-3 and 3-5 GeV/c
  - $|\Delta\eta|<0.7$

$\Delta\eta$ correlation in near-side



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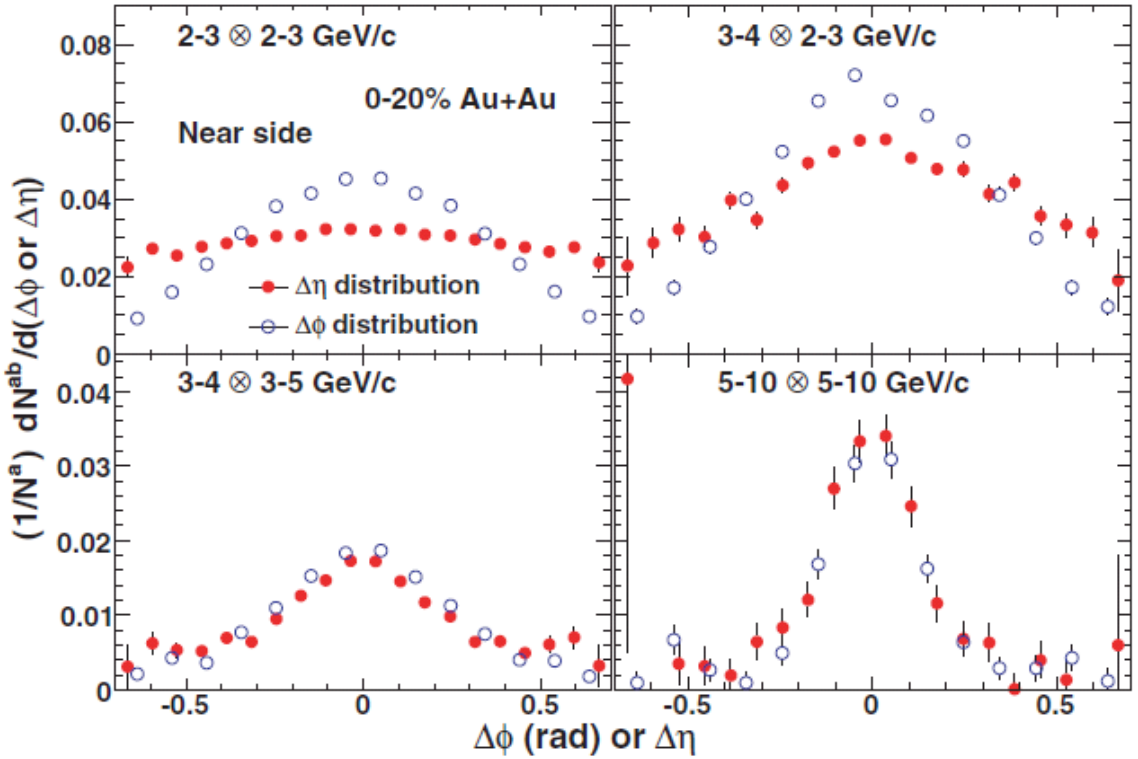
- The ridge exists at low partner pT
- Au+Au is consistent with p+p at high partner pT

$\Delta\eta$ vs $\Delta\phi$ in near-side



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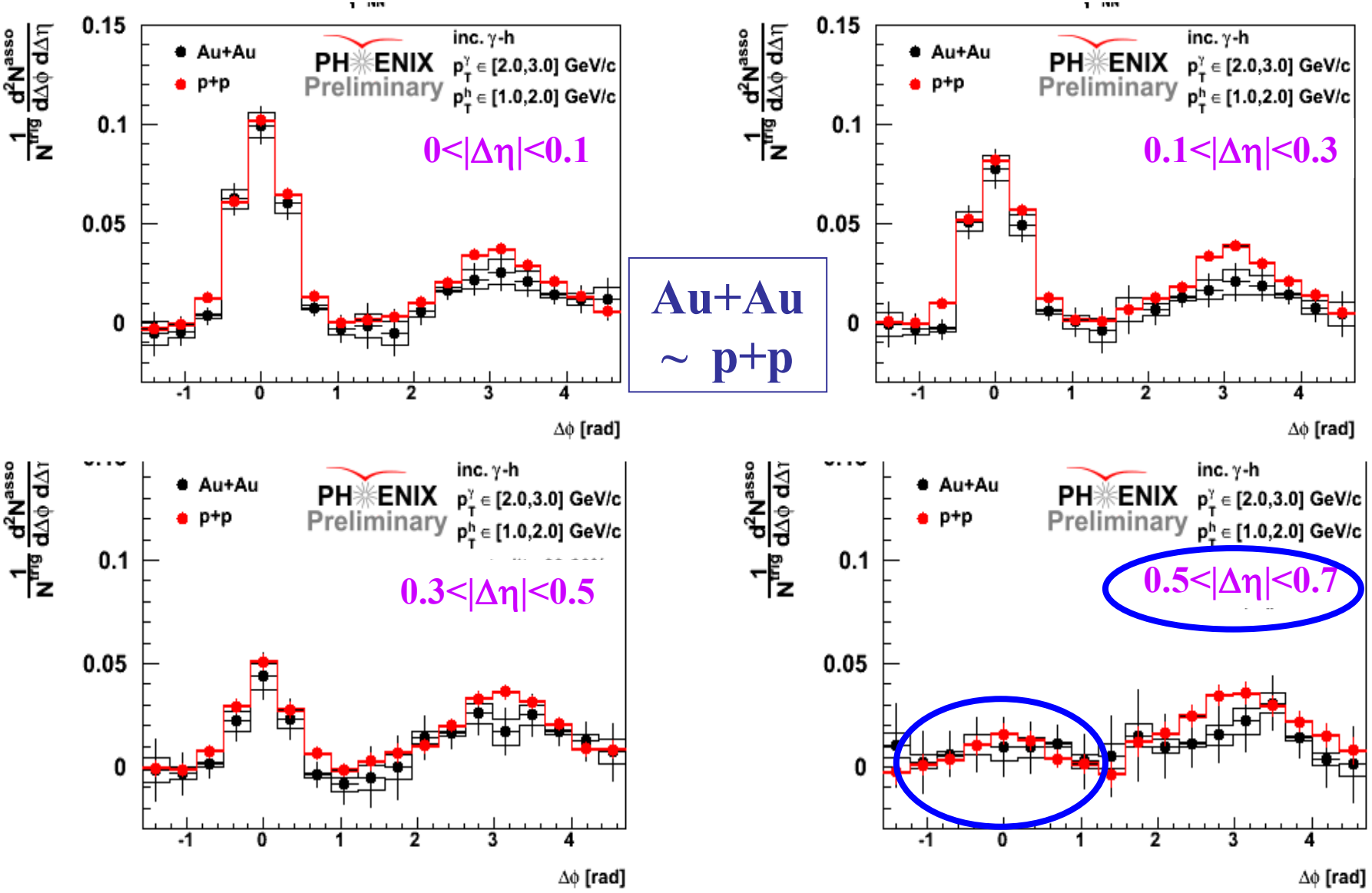
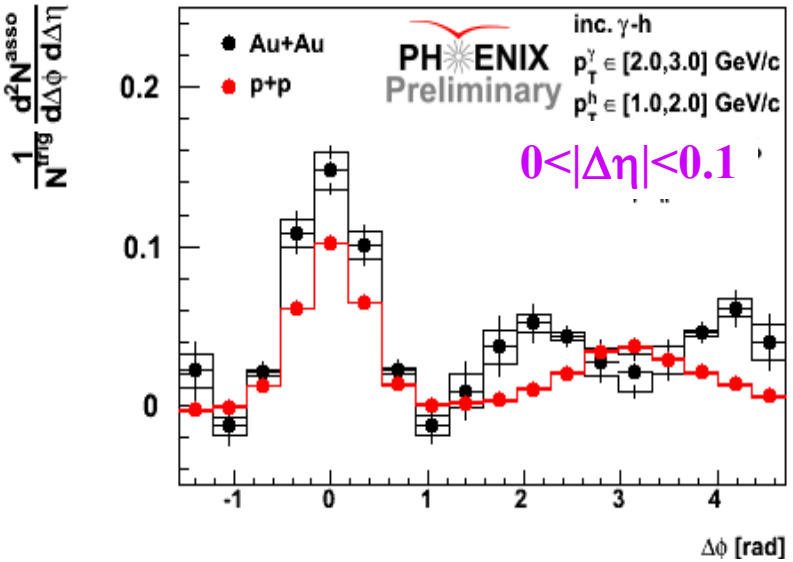
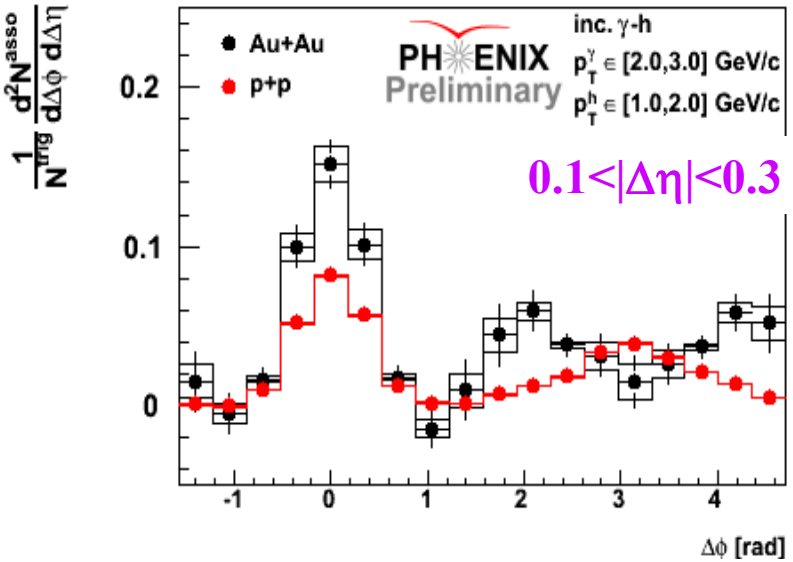
- The ridge extends only in $\Delta\eta$ direction

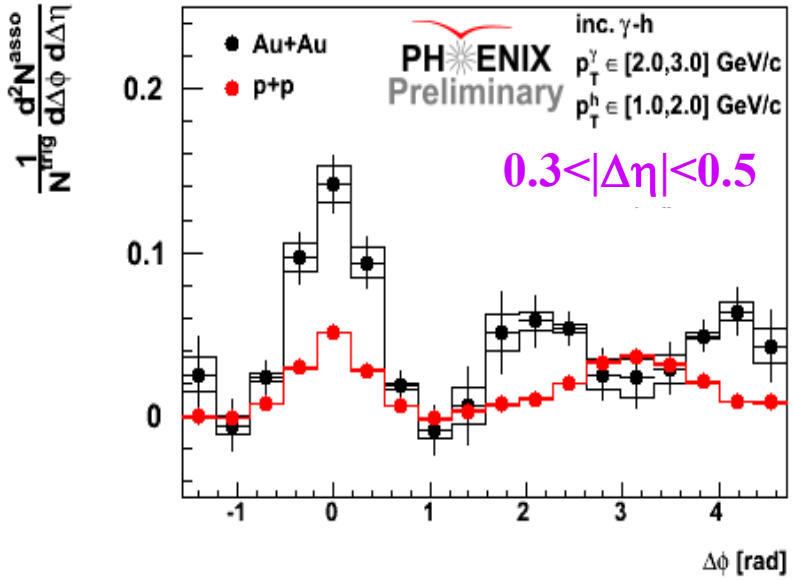
Yield in $\Delta\eta$ slices: peripheral

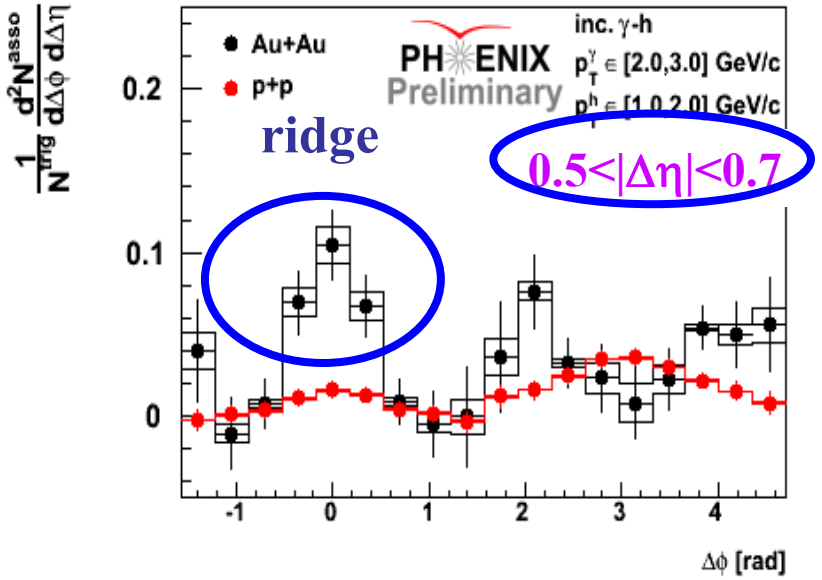


Yield in $\Delta\eta$ slices: 0-20% central

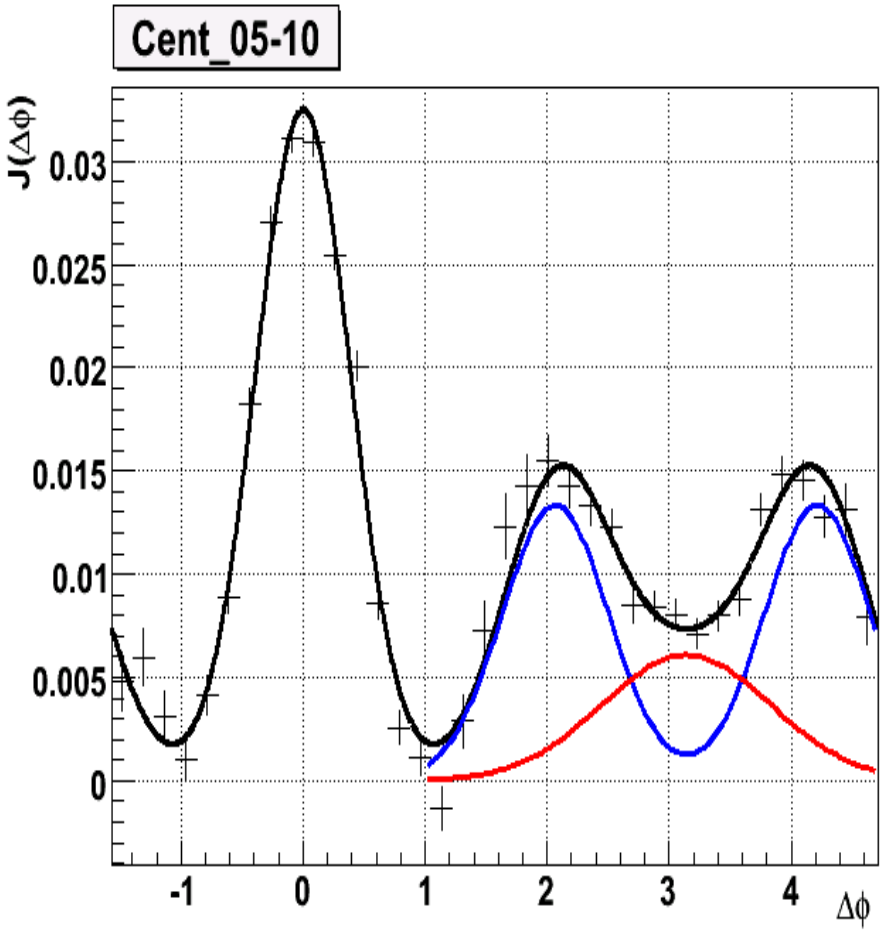






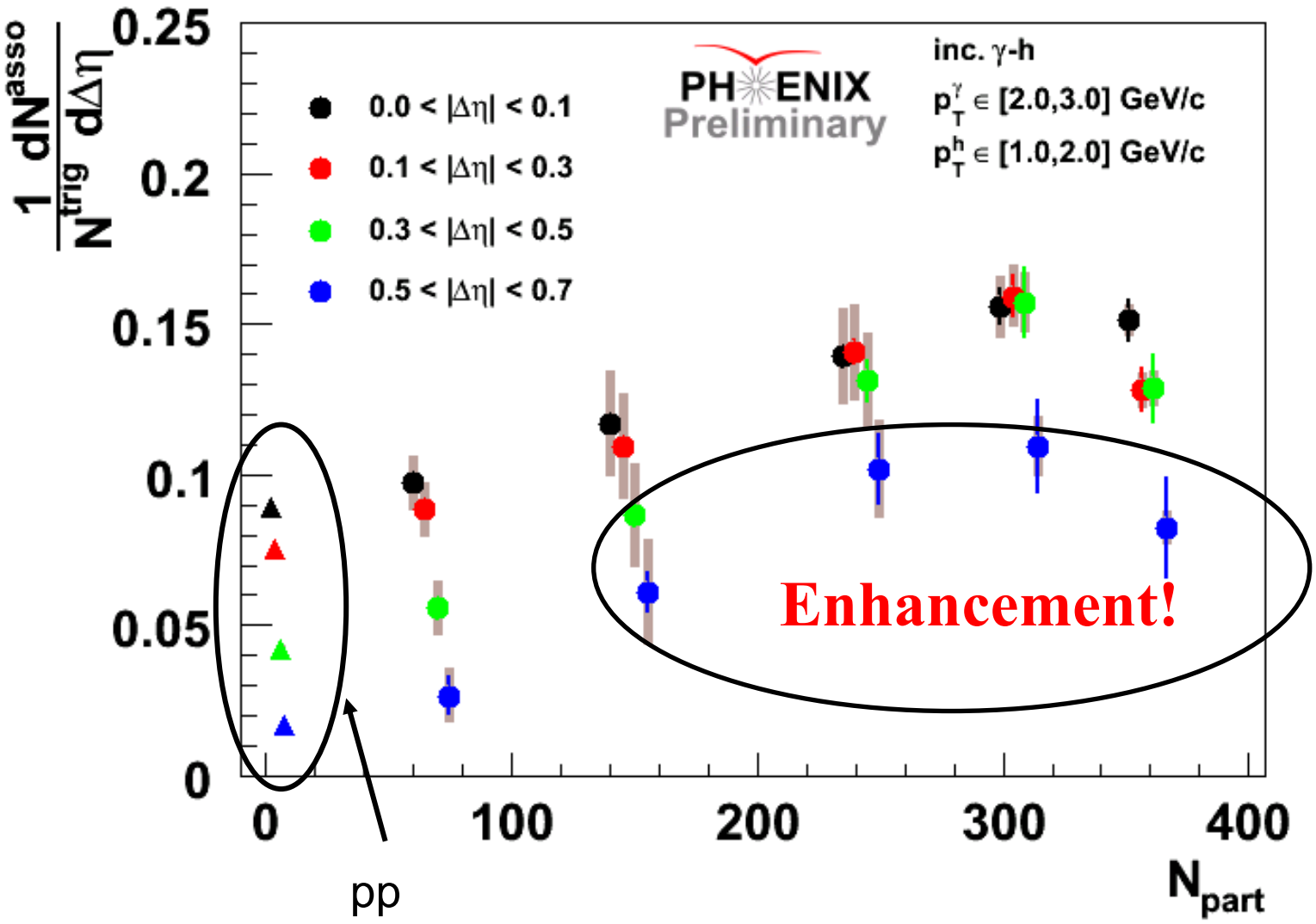


Decomposition method

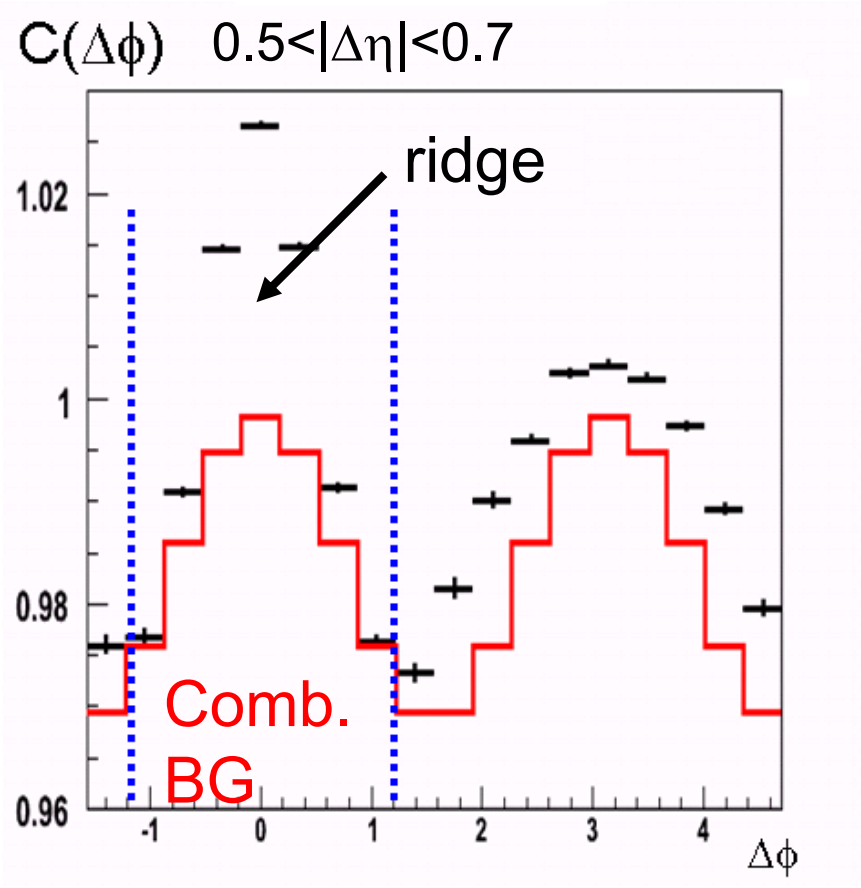


- Fit away side jet with sum of three Gaussians to decompose components:
- Treat all components as Gaussian in shape
- Use ZYAM method to fix background level
- Head: punch through jet
- Shoulder: new peak either side of π (medium response ?!?!)

nearside enhancement vs centrality

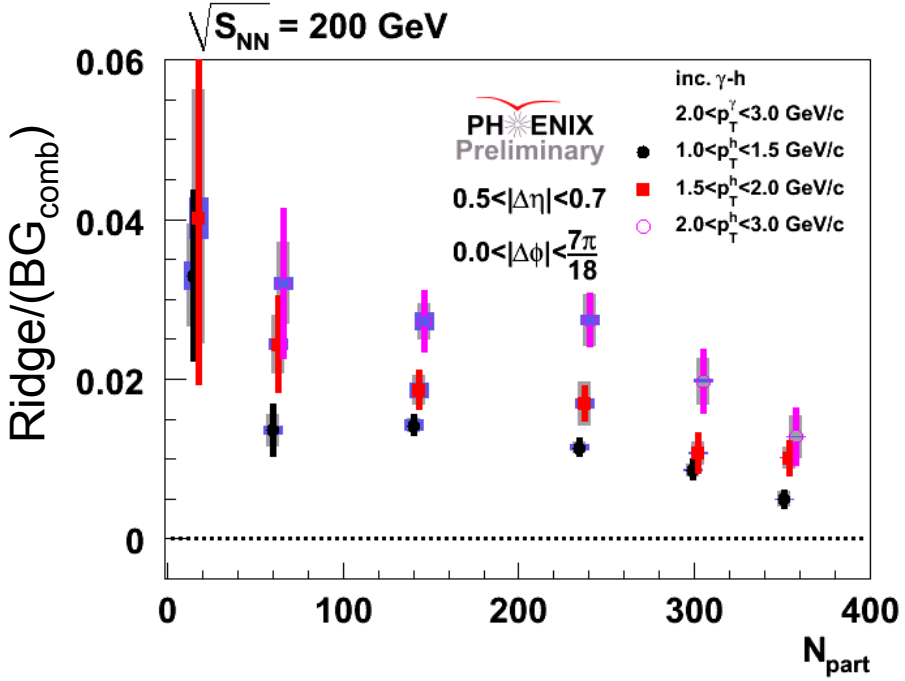


Is Ridge similar to bulk?



Ratio
= ridge /(Comb. BG. in nearside)

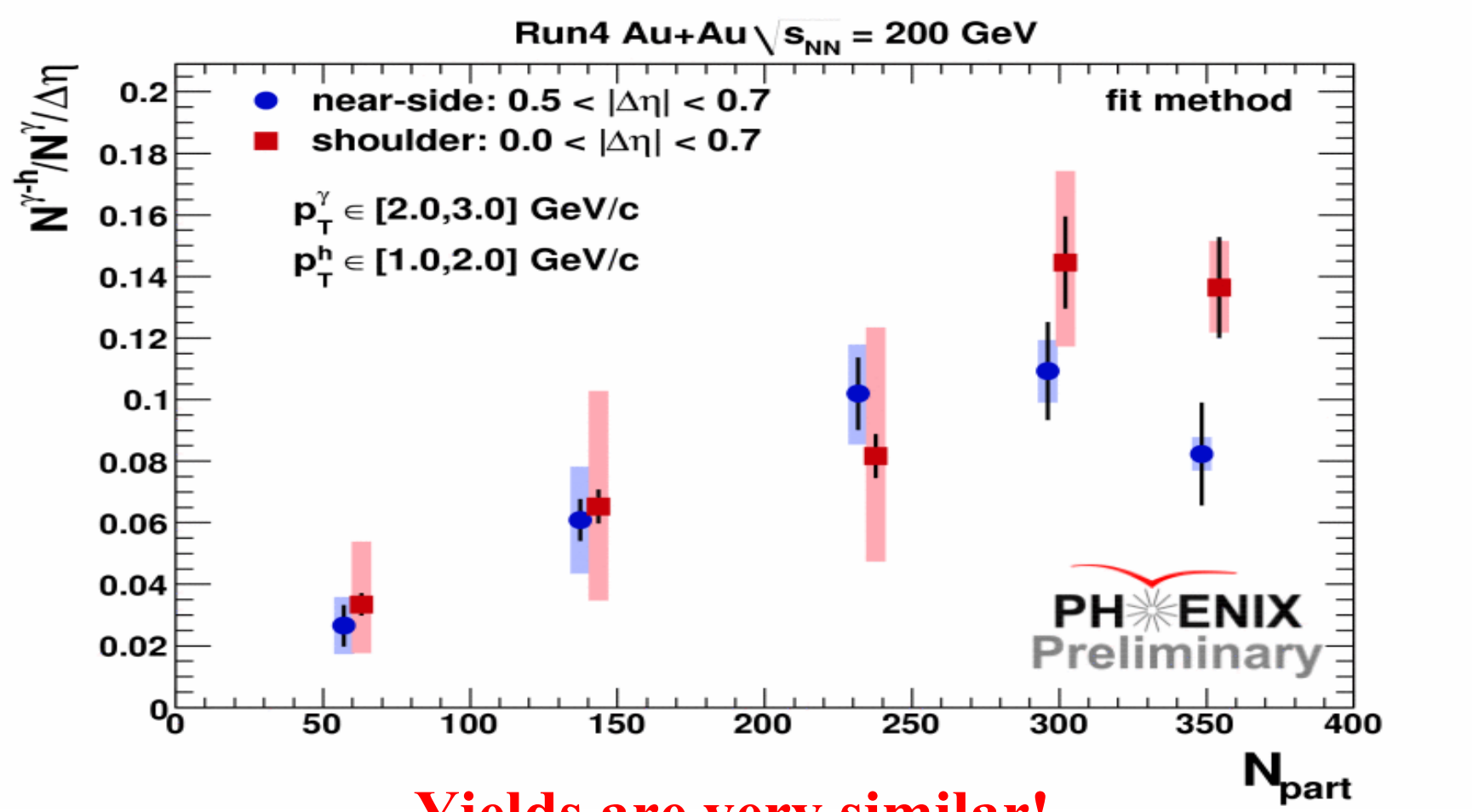
Ridge/background ratio



N_{part} ↑ , ratio ↓

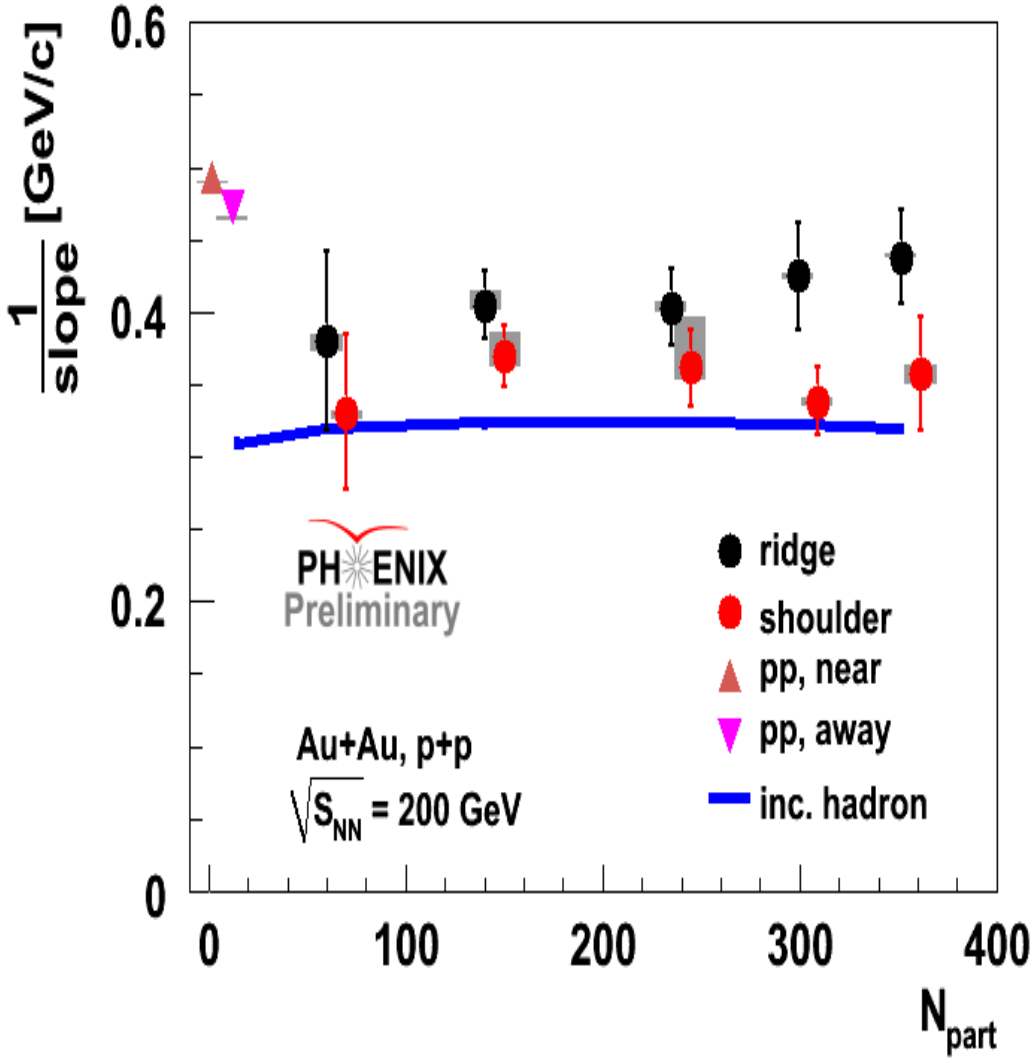
Y_{ridge} changes from 3% to 1% of the bulk when increase N_{part}

Ridge & shoulder both increase with centrality



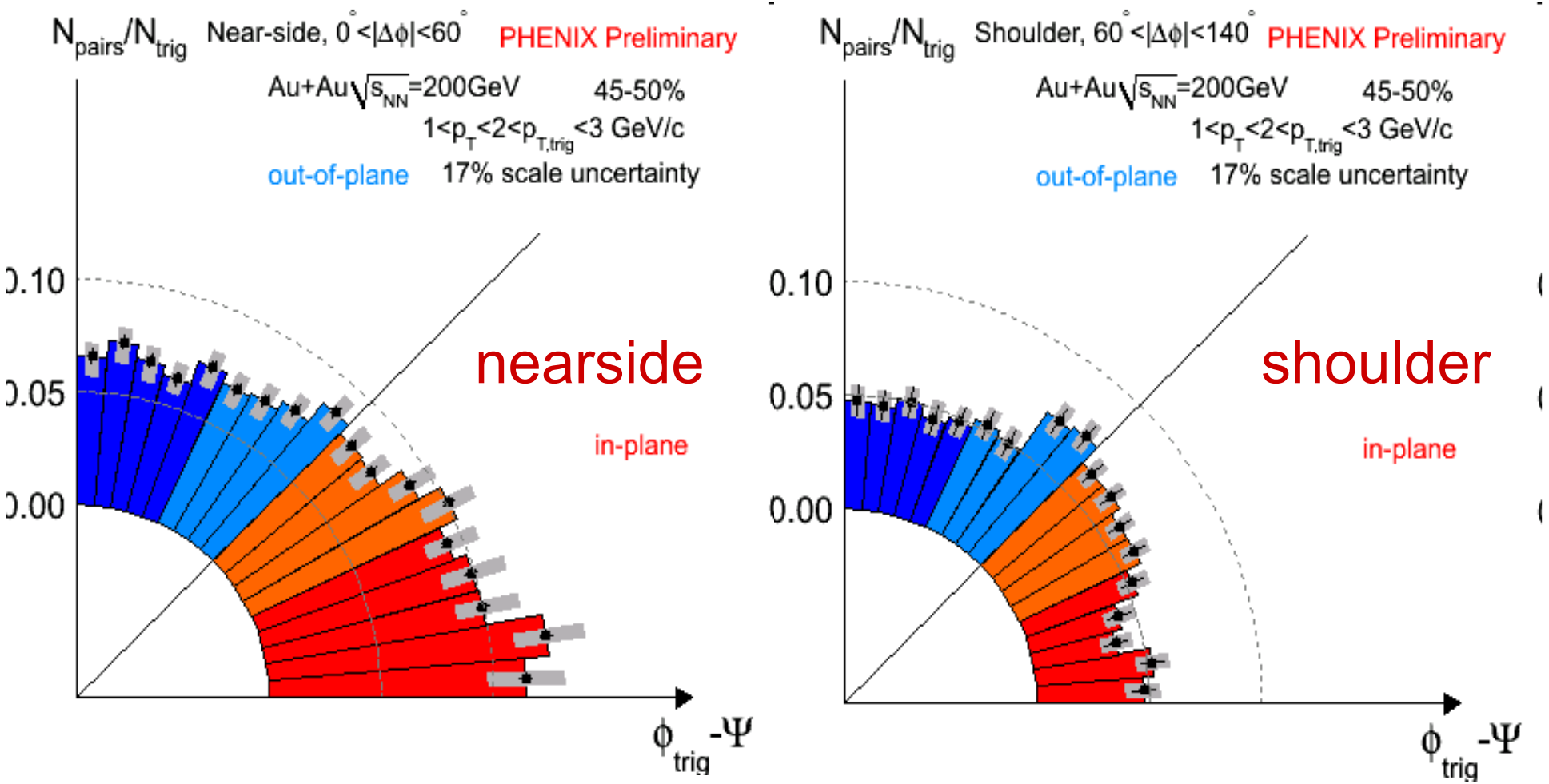
Yields are very similar!

Shoulder & ridge p_T spectra vs. p+p



- Both are softer than hard scattering.
- Ridge harder than shoulder?
- Shoulder not quite as soft as inclusive hadrons

Nearside/shoulder vs reaction plane

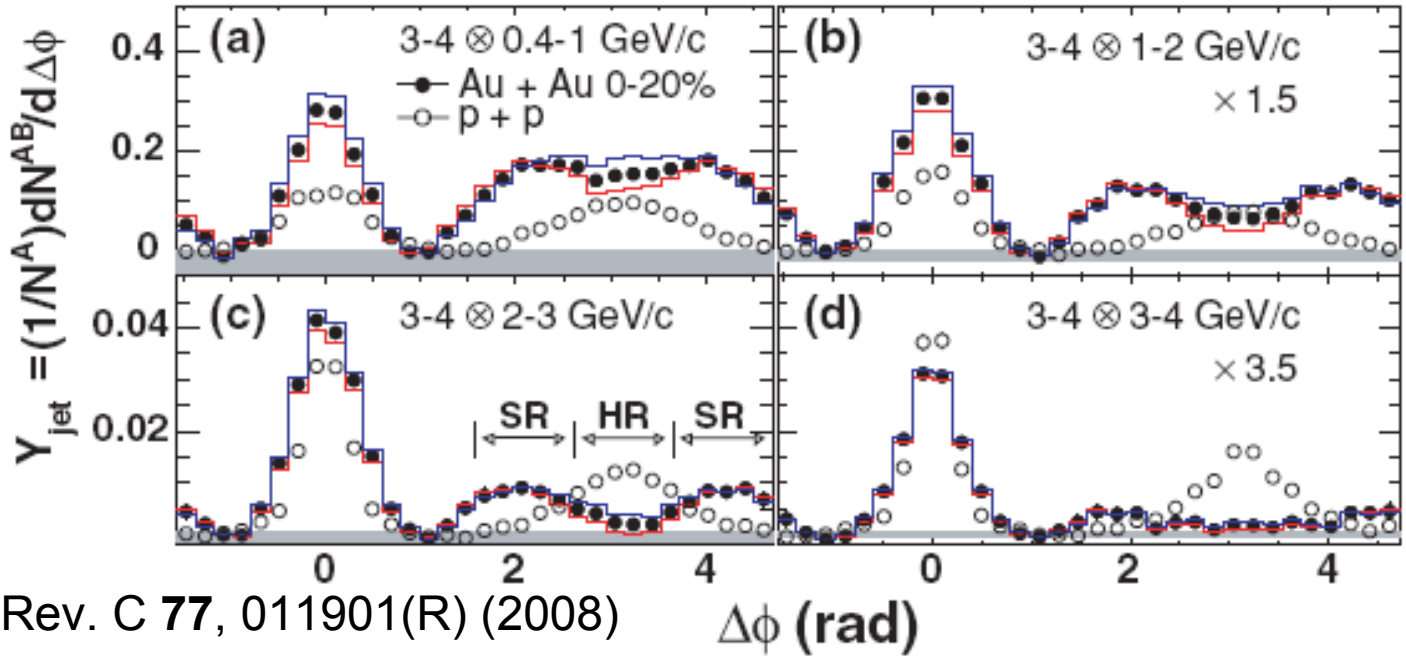


- Different reaction plane dependence in nearside and shoulder!

How do theorists think?

- Ridge :
  - Fluxtube?
  - Longitudinal flow?
  - Radial flow?
  - Back splash?
  - Momentum kick?
  - Recombination?
- Shoulder:
  - Mach cone?
  - Recombination?
  - Radial flow?

Where does the momentum go?



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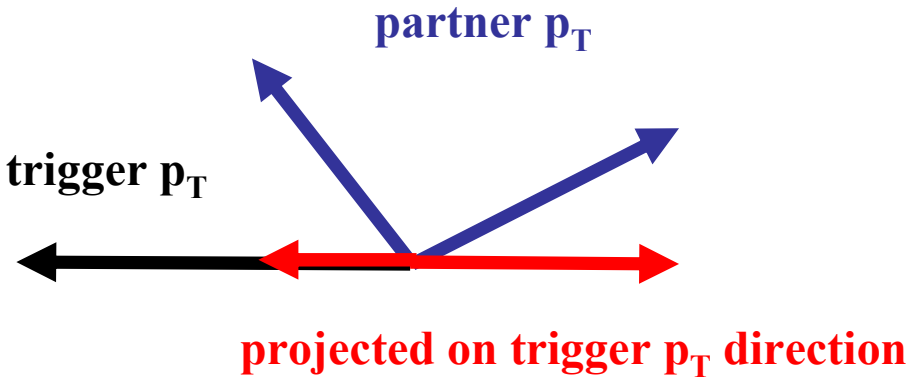
- Compare to pp, the awayside per trigger yield at high p_T is suppressed.
- At lower p_T, the awayside yield is enhanced.
- During the collision, the total transverse momentum is conserved
  - How does the jet momentum redistribute into the medium?

Momentum flow

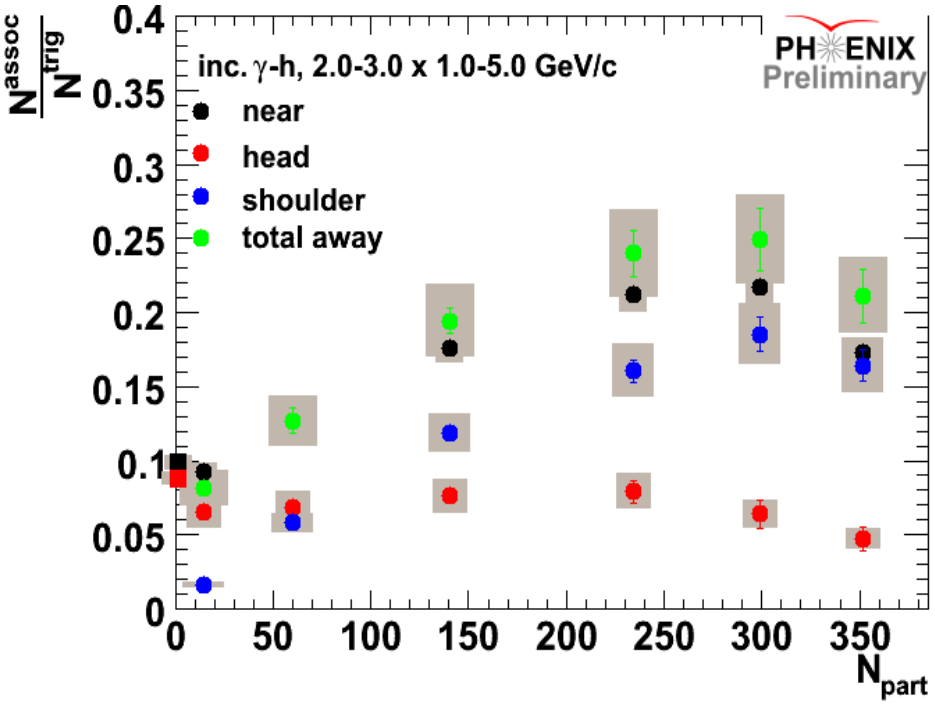
- Weight the per trigger yield of each partner p_T bins with $\langle p_T^{assoc} \rangle$
- $\rightarrow$ Ensemble averaged vector sum of associated particles.

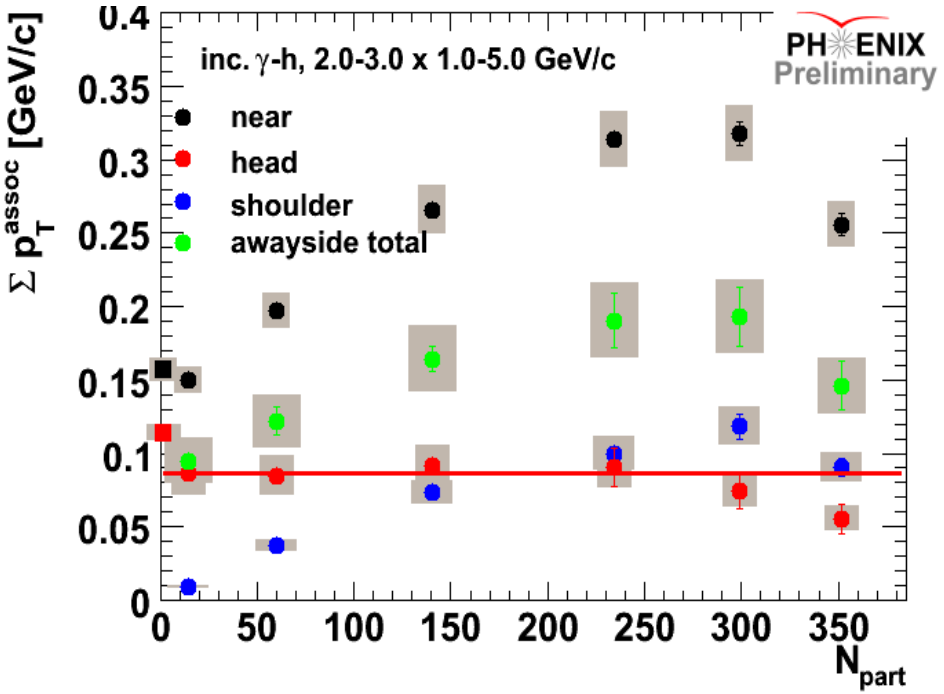
  Vector sum is along the trigger direction
- e.g.

$$p_{T,near,total} = p_{T,ave} \int_{-\pi}^{\pi} \cos(\Delta\phi) \frac{Y_{near}}{\sigma_{near}\sqrt{2\pi}} exp(-\frac{(\Delta\phi)^2}{2\sigma_{near}^2}) d(\Delta\phi)$$



Near & away increase with centrality



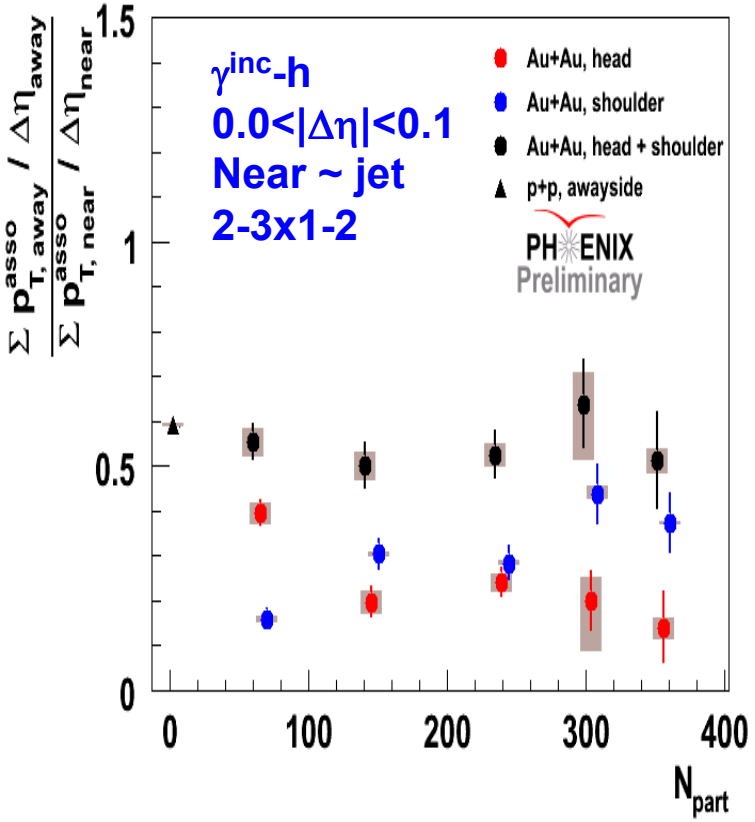


Number of particles ⟶ **p_T Weighted yield**

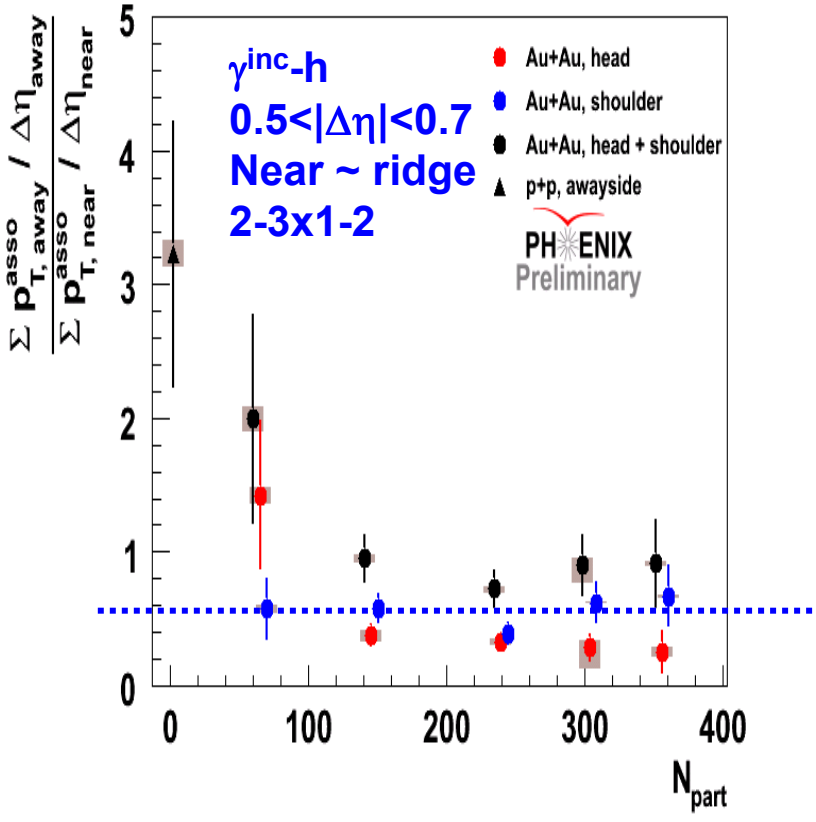
Where does the momentum go?

$$p_T \text{ ratio } (\Delta\eta) = \frac{p_T \text{ carried by awayside component per } \Delta\eta}{p_T \text{ carried by nearside component per } \Delta\eta}$$

awayside: head, shoulder, total awayside



Awayside p_T lost in head is recovered in shoulder



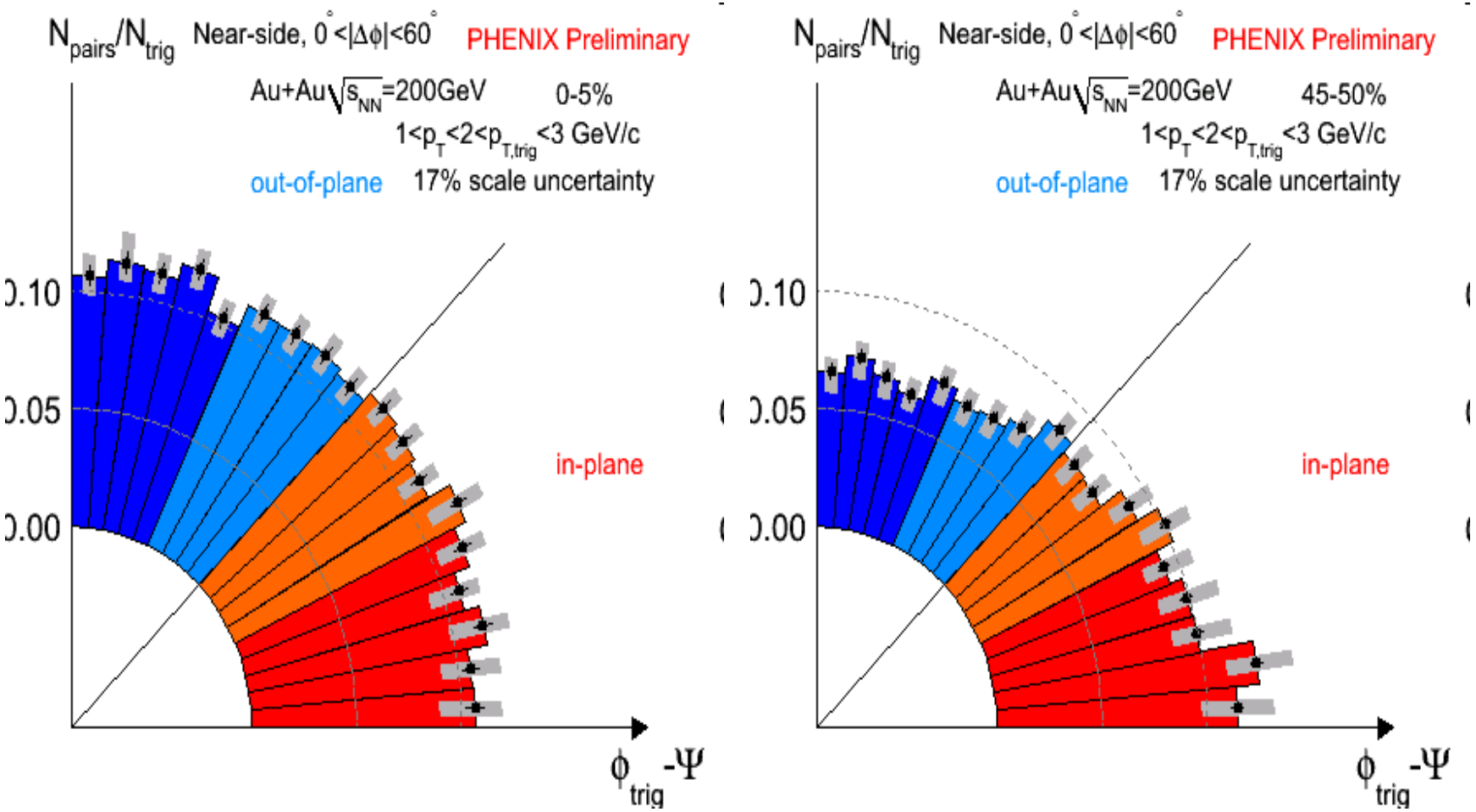
The p_T carried by ridge scales with the p_T carried by shoulder

Summary

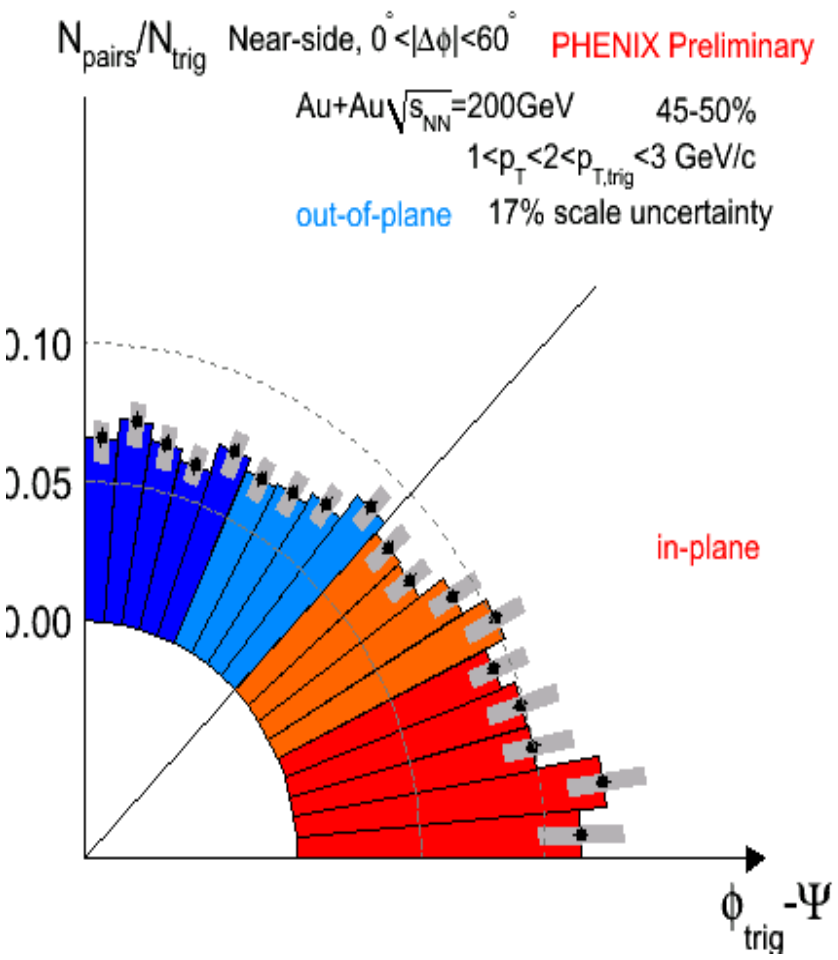
- Ridge and shoulder are:
  - Similar in yields
  - Similar in inverse slope (ridge is harder)
  - Softer than hard scattering
  - Harder than inclusive hadron
  - Different in reaction plane dependence
- The momentum sum of head and shoulder scales with nearside in central $\Delta\eta$ region
- The pT carried by ridge scales with the pT carried by shoulder

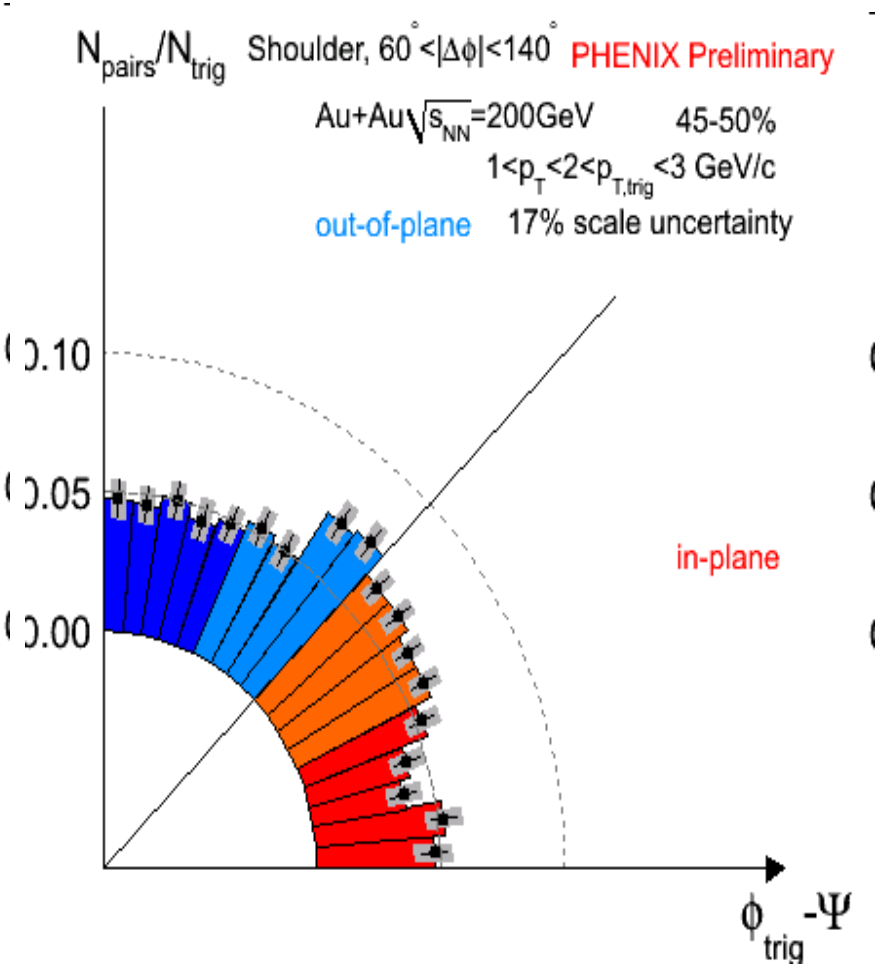
Backup slides

Nearside yield vs reaction plane



Ridge yield is reaction plane dependent!


N_{pairs}/N_{trig} Near-side, $0^\circ<|\Delta\phi|<60^\circ$ PHENIX Preliminary
Au+Au $\sqrt{s_{NN}}$=200GeV 45-50%
$1<p_T<2<p_{T,trig}<3$ GeV/c
out-of-plane 17% scale uncertainty
0.10
0.05
0.00
in-plane
ϕ_{trig} -Ψ


N_{pairs}/N_{trig} Shoulder, $60^\circ<|\Delta\phi|<140^\circ$ PHENIX Preliminary
Au+Au $\sqrt{s_{NN}}$=200GeV 45-50%
$1<p_T<2<p_{T,trig}<3$ GeV/c
out-of-plane 17% scale uncertainty
0.10
0.05
0.00
in-plane
ϕ_{trig} -Ψ